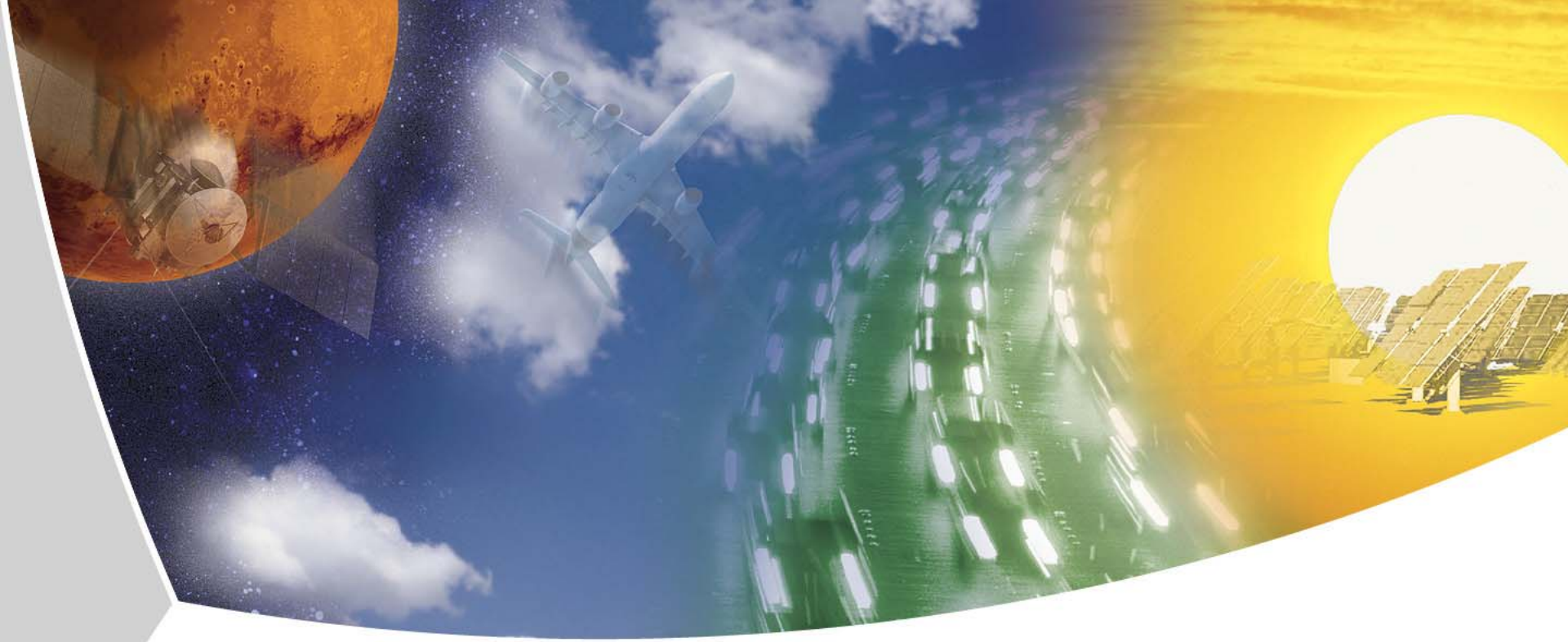


Astroparticle Physics, Cosmic Ray Physics and Space Situational Awareness

Frank Jansen
DLR Institute of Space Systems, Bremen, Germany

e-mail: frank.jansen@dlr.de
Inputs by Medipix Consortium
S. Pospisil CTU Prague & K. Kudela IEPSAS Kosice

Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

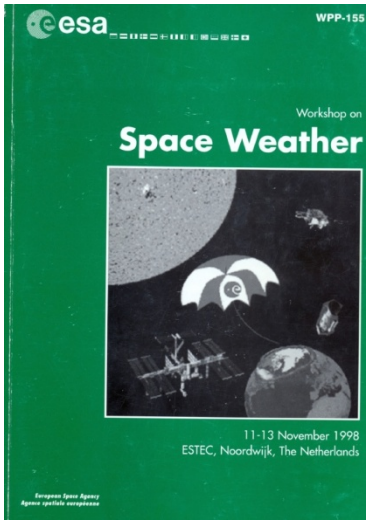
Content

1) Space Situational Awareness (SSA)

2) High Energy Galactic & Solar Cosmic Ray Data / Models

3) Forecast of SW storms and
Microphysics Detector Technology Applications in SSA

1. Space Situational Awareness



1998 … 2008:
ESA / ESTEC

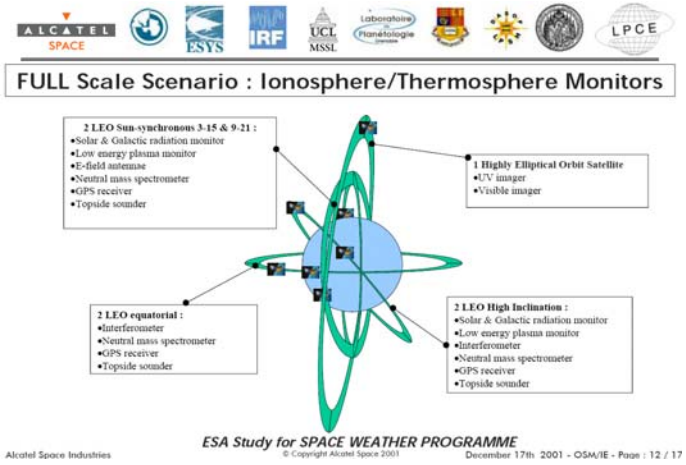
2000: http://www.swissre.com/

esa

ESA Space Weather Studies

CLRC

ALCATEL SPACE



2000 / 2001 : SW Feasibility Studies

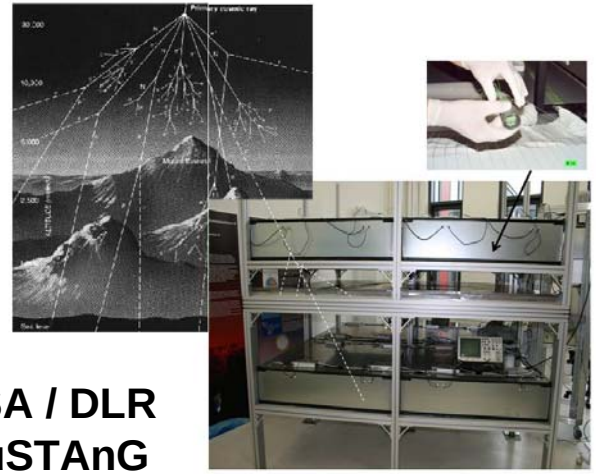
DLR

1. Space Situational Awareness

2003: ESP White Paper

2007 / 2009: EU / FP6 SWEETS DVD

2002 / 2003: EU / FP 5 SWE (Space Weather and Europe)

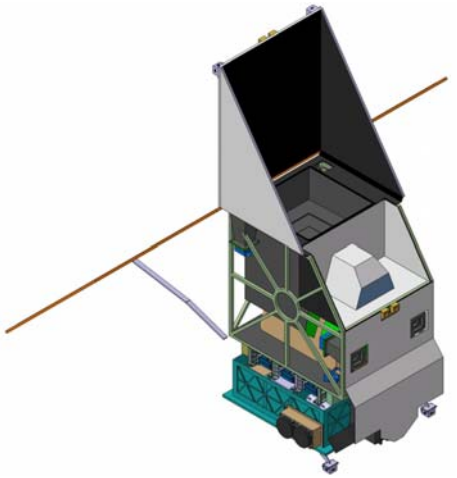


2004 - 2006: ESA / DLR MuSTAnG

1. Space Situational Awareness

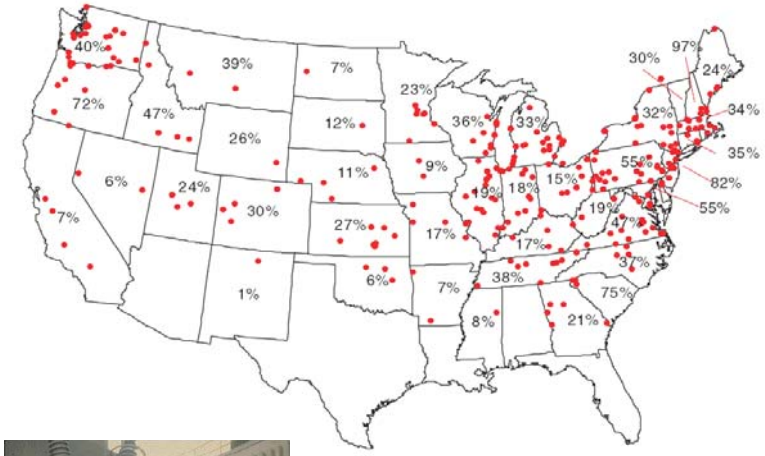
2008 - 2018: EU – ESA SSA

1) NEOs

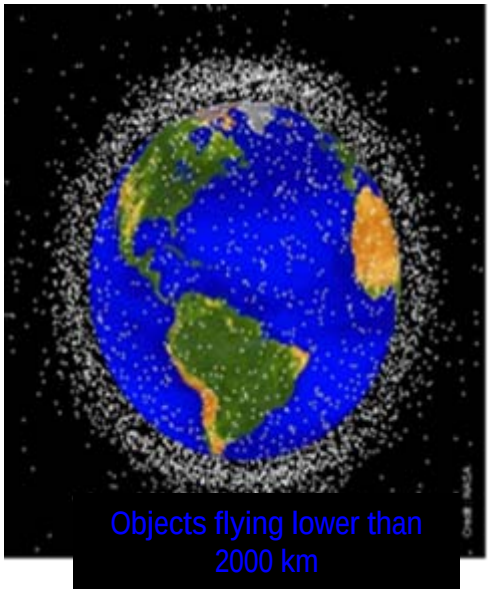


DLR Bremen
AsteroidFinder
Phase A & B

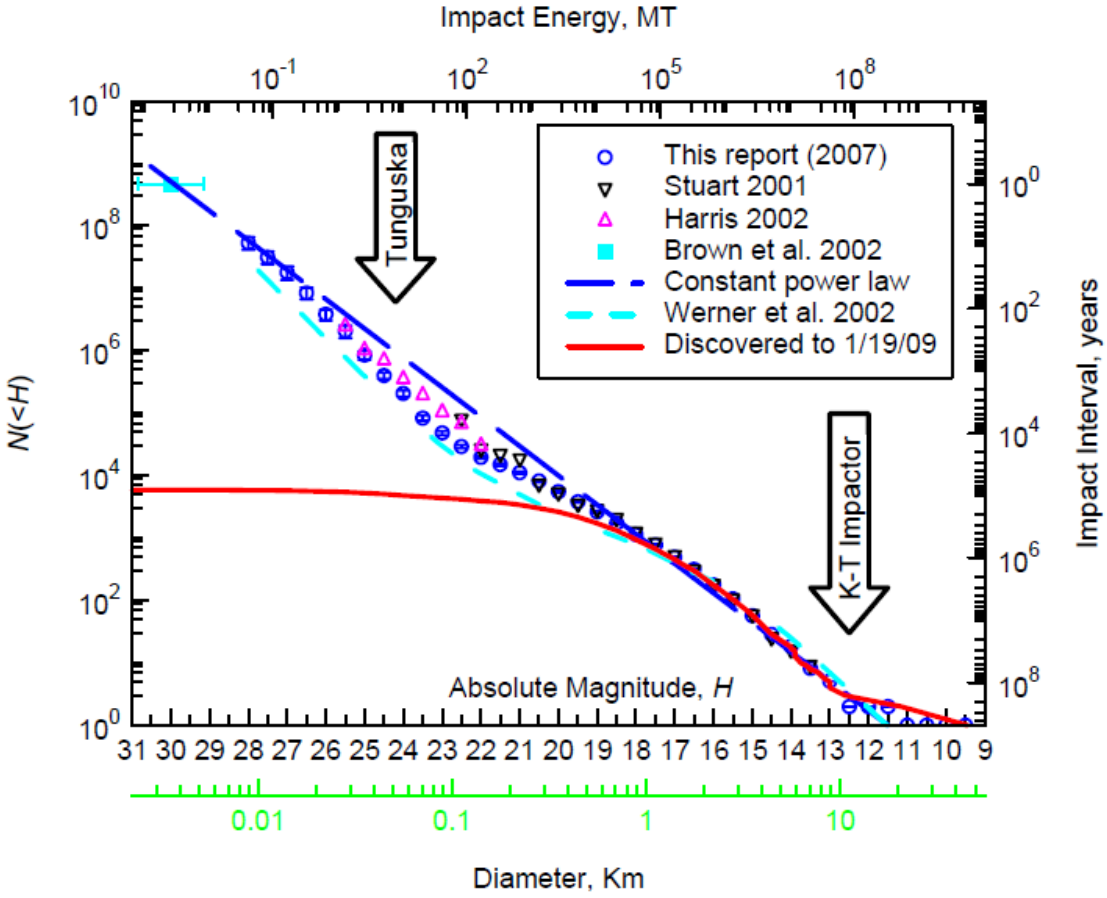
2) Space Weather

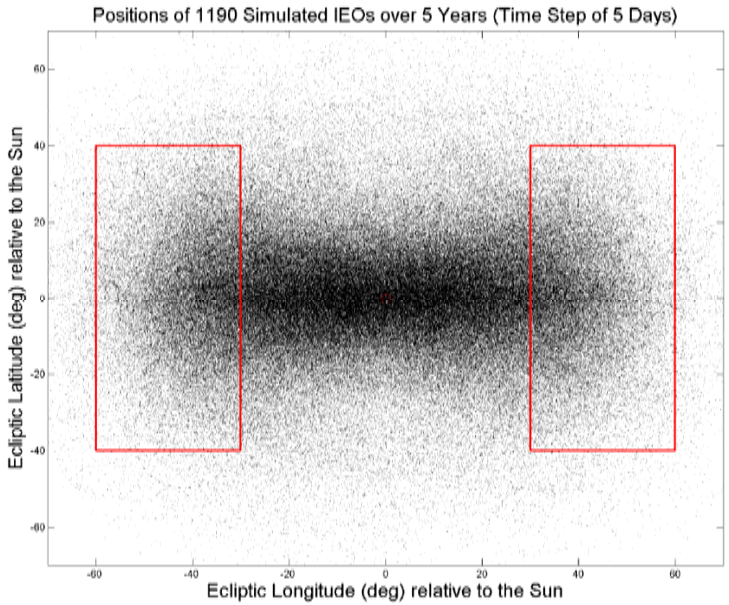


3) Space Debris



1. Space Situational Awareness: NEO / IEO

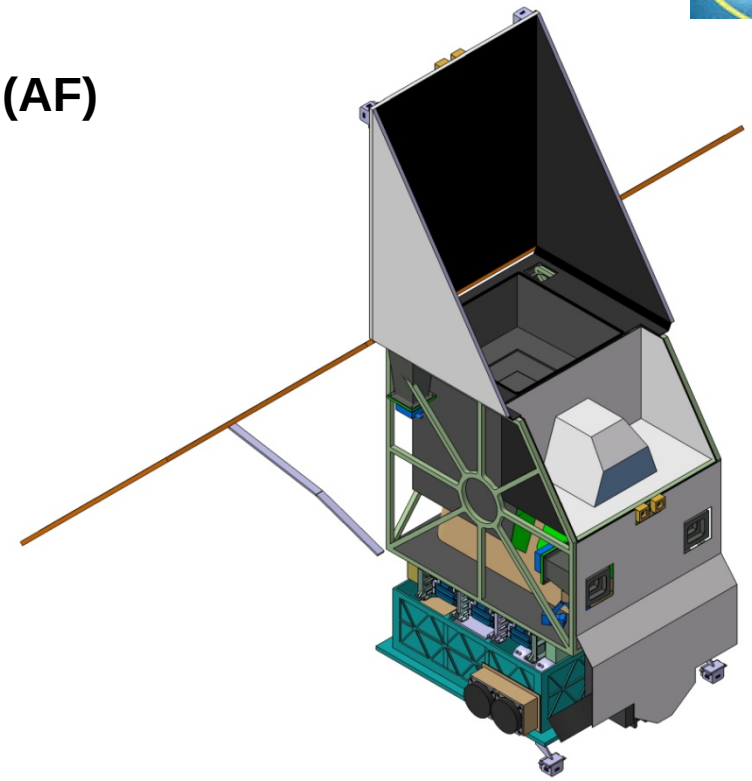


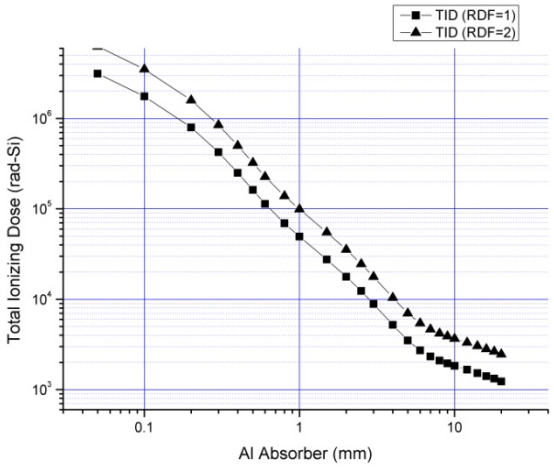


1. SSA and NEO: DLR AF

Compact satellite AsteroidFinder (AF)

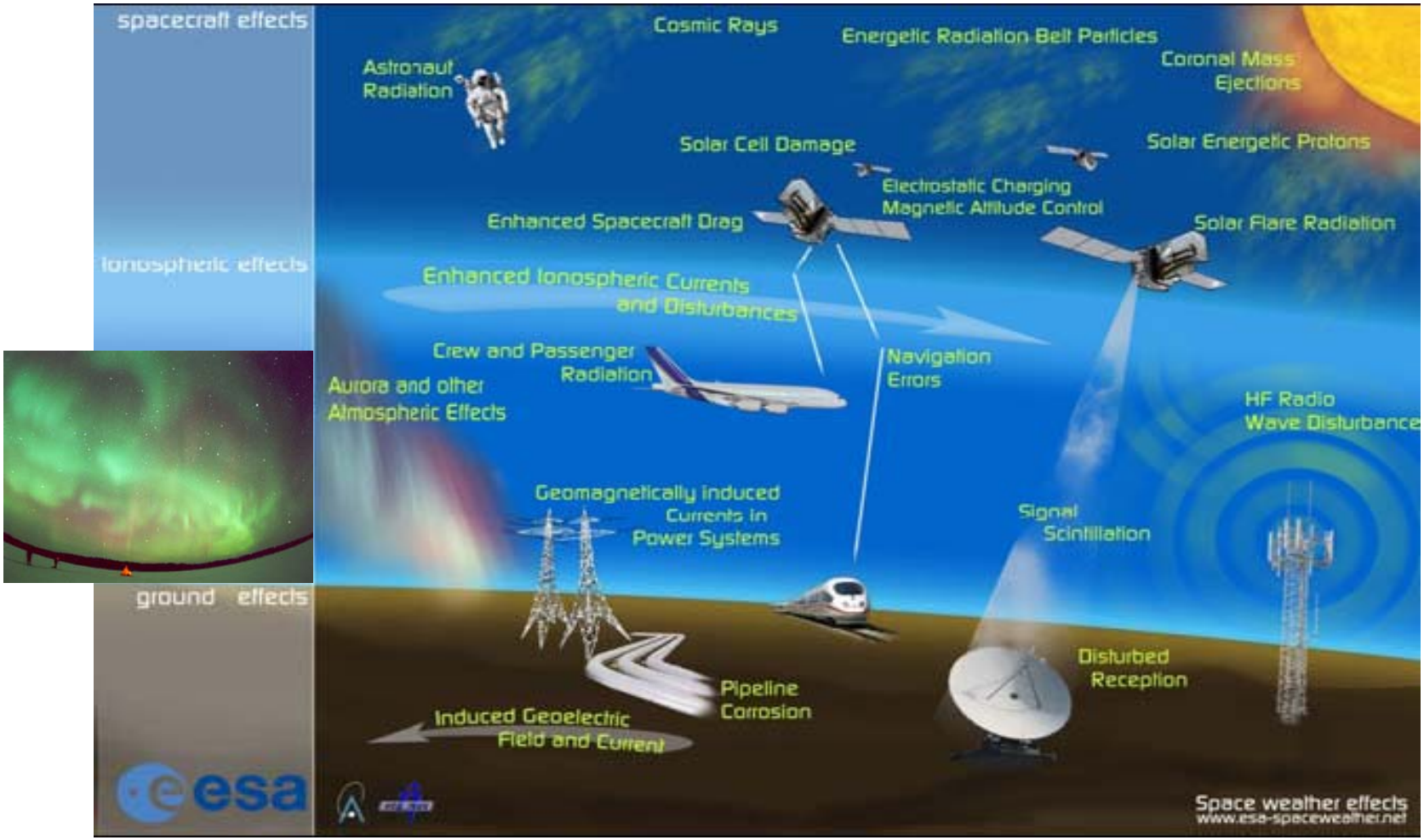
- satellite bus based on BIRD (TET)
- phase A finished
- phase B in 2009
- launch in 2012
- to be operated by GSOC





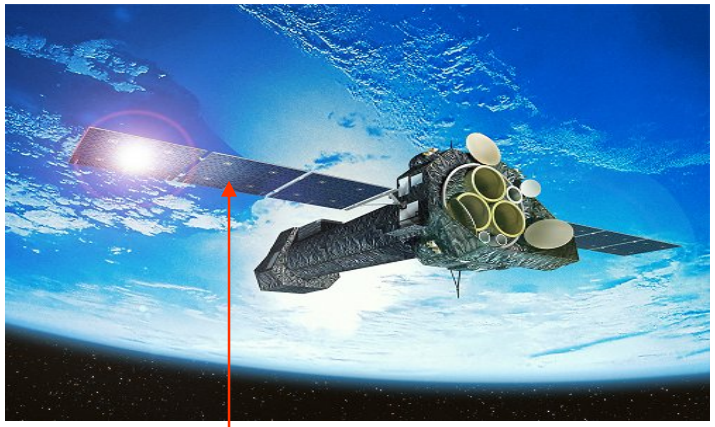
- CREME 96 + SPENVIS
- TID (trapped + solar particles)
- 3 years at 850 km orbit

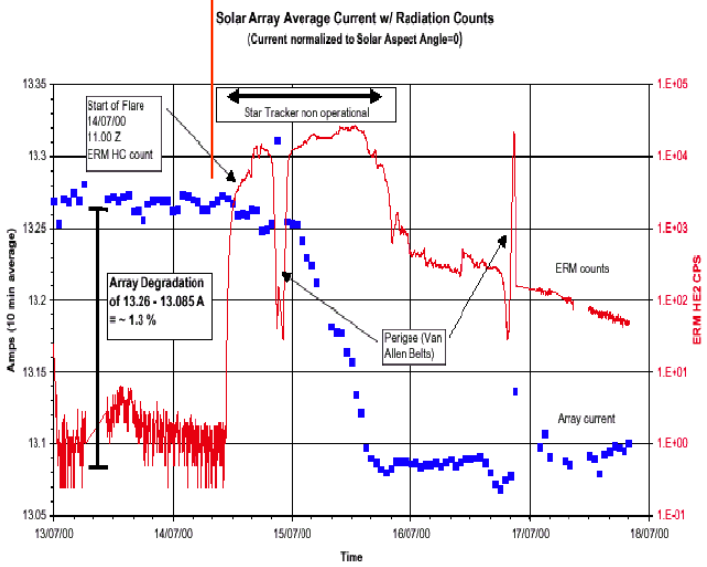
1. Space Situational Awareness



SW effects

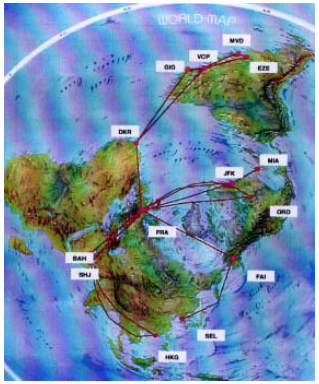
1. Space Situational Awareness: Space Effects

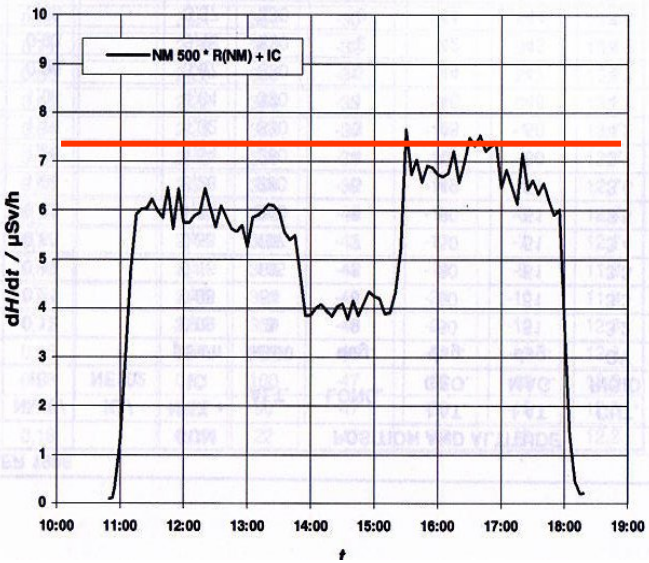




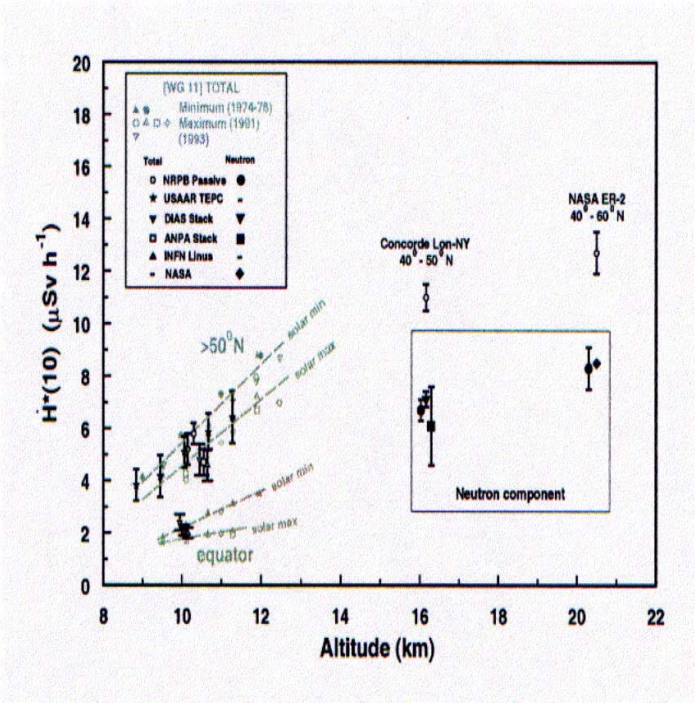
- 31 failures and losses (12 total losses)
  Meteosat, ERS-1, XMM ...
  Equator-S, Anik 1&2,
  Telstar 401, ASCA ...
- losses in 4 years more than 500 Millionen USD

1. Space Situational Awareness: Aircraft Effects



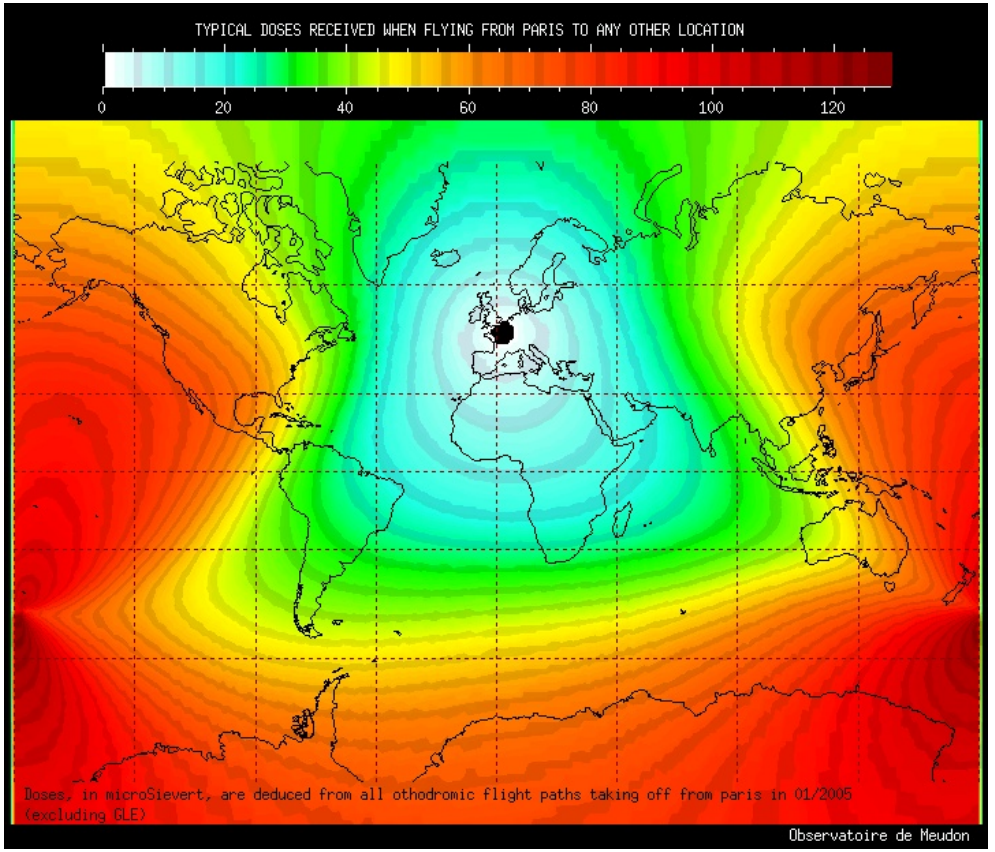


flight Chicago – Frankfurt 4 Oct 98 (PTB)

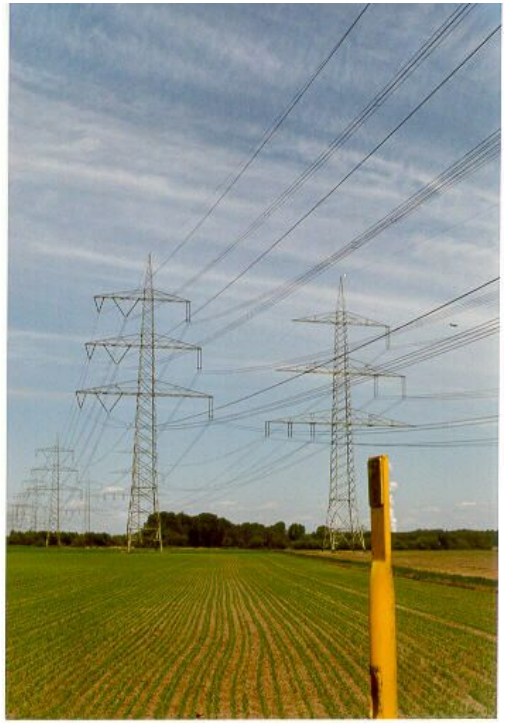


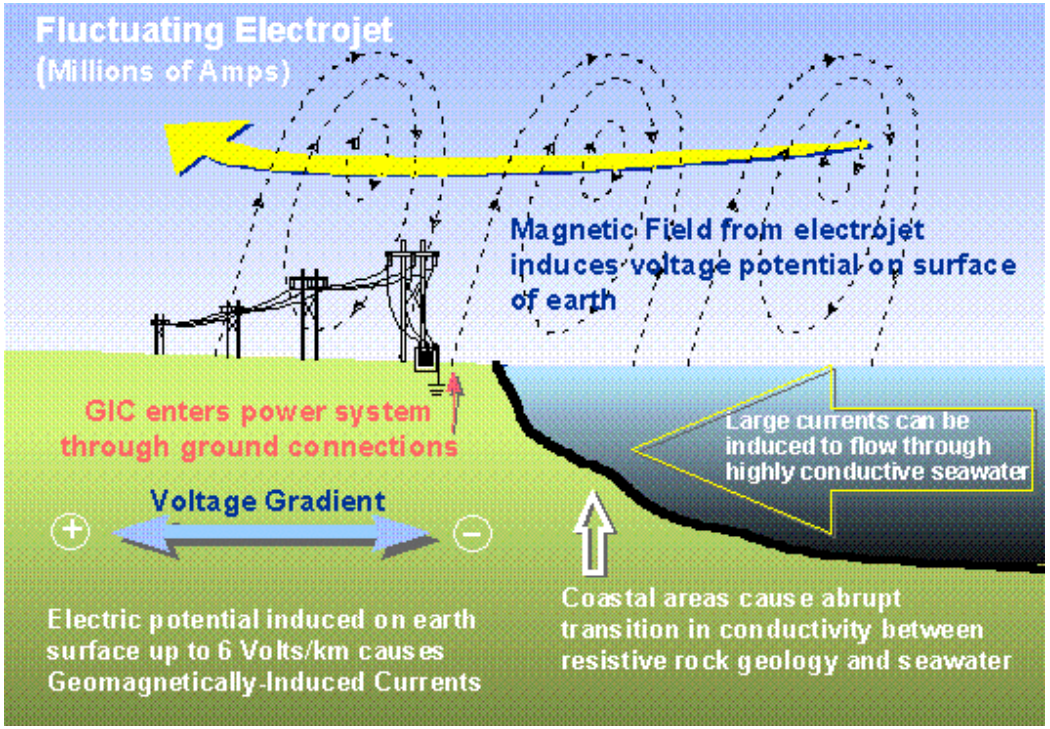
- European regulation
- in Germany new radiation law (BfS, BMU)
  since 1 June 2001:
  airline have to estimate the radiation exposure
  (effective dose 1 mSv,
  upper limit 20 mSv per year)

1. Space Situational Awareness: Your CR Dose



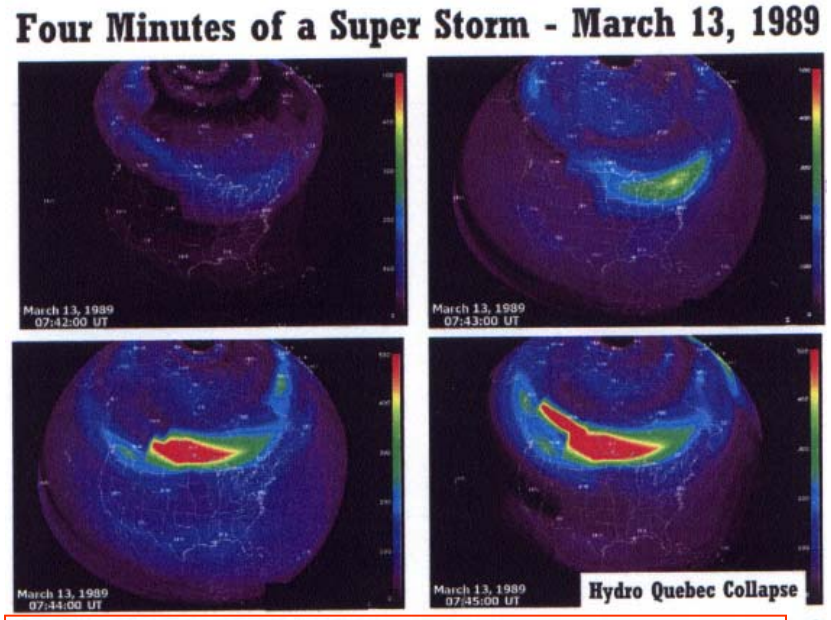
1. Space Situational Awareness: GICs





1. Space Situational Awareness: Power Cut

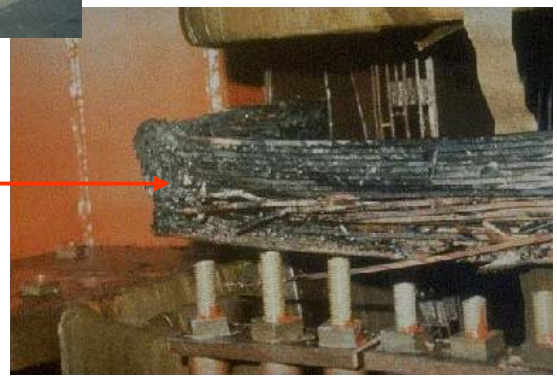
- **Power supply: 13 March 1989 – just before the blackout**



- Hydro Quebec: collapse time 90 sec ! (400nT/min)
  (9 h power blackout for milion people in winterr)
- 865 nT/min measured in Minnesota!

-normaly 3000 A
-several amps => unsufficient working regime of the transformator
- 200 A measured in trafo.

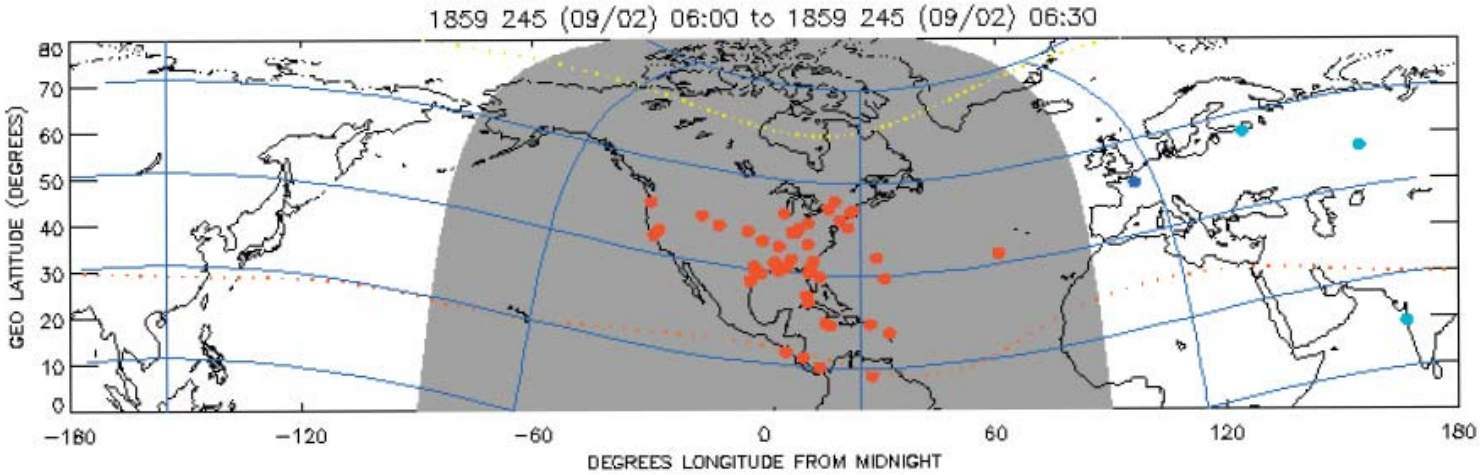
New Jersey



10 Milliarden USD

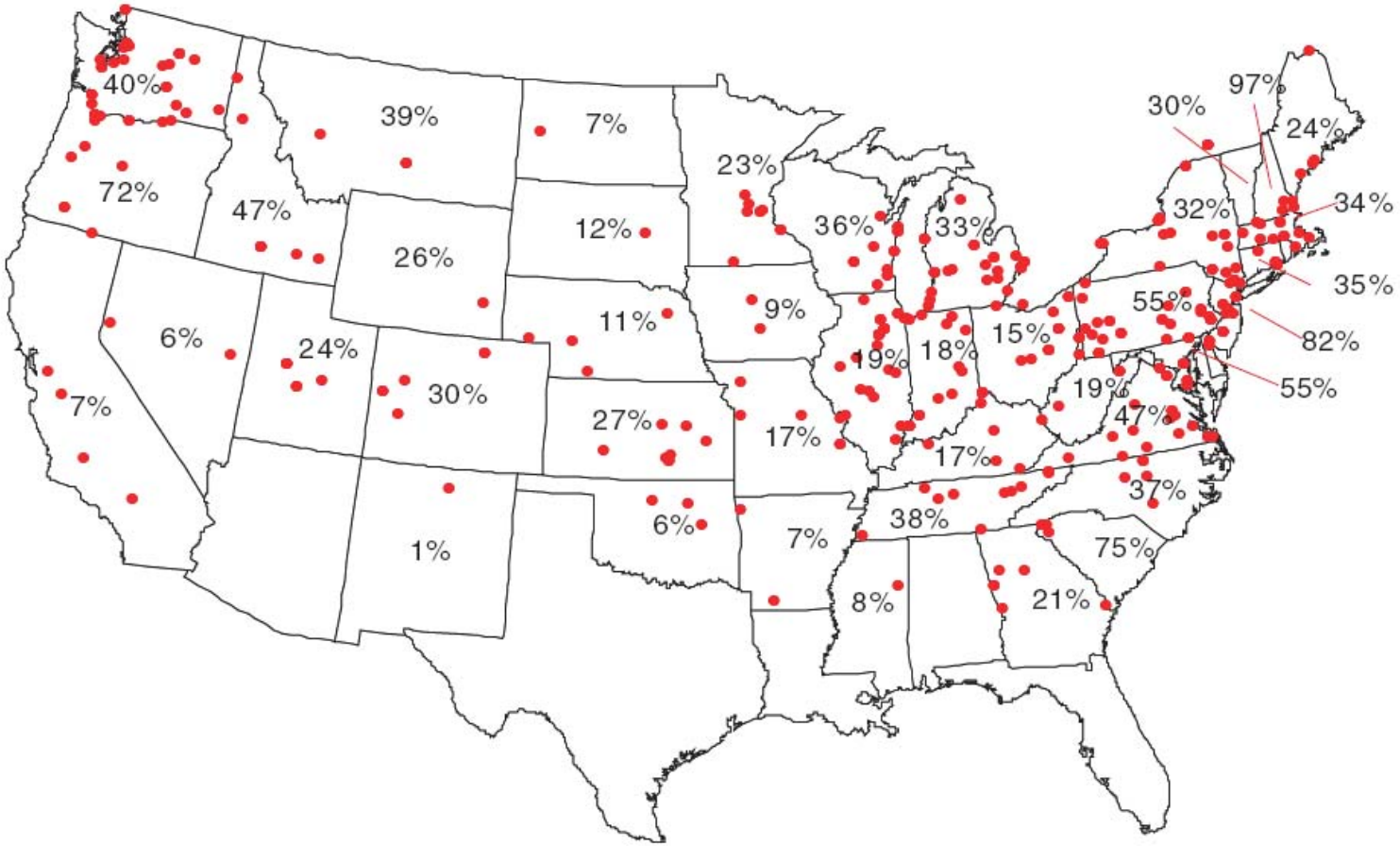
-Rep.: 10 Mill. USD (up to one year, here only 6 weeks)
-Sweden: 6 130- kV-l power line
-Cu-coils up to 3000 A
-April 94: 5 transformatoren in Chicago
-Finnland: 143 amps measured in power lines

1. Space Situational Awareness: Space Catrina 2 September 1859 – and today?

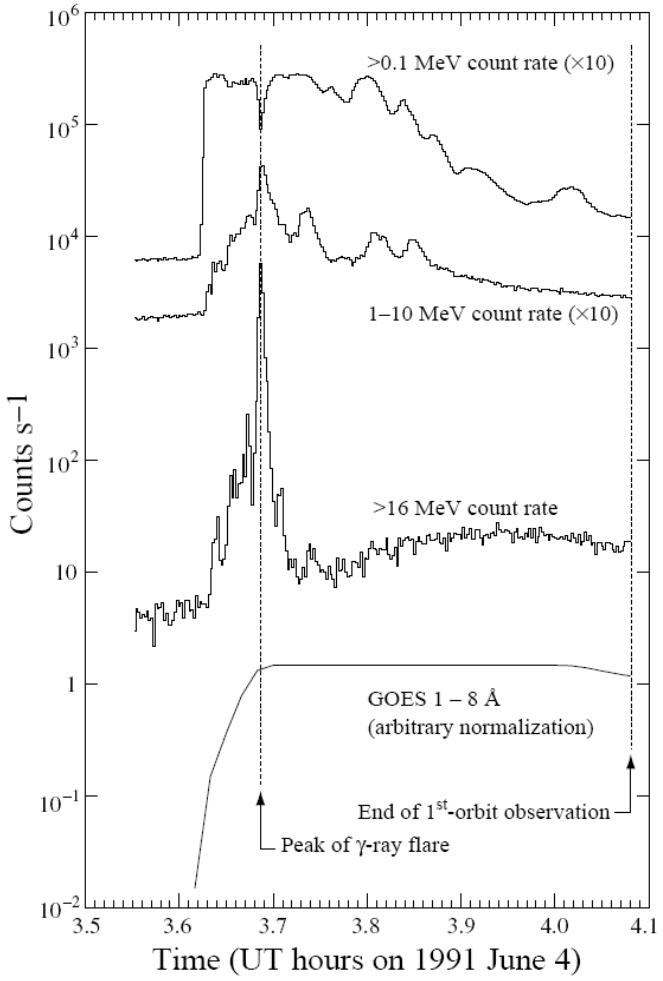


- Catrina: 81 – 125 Bill. US $
- sw super storm sturm: 1 – 2 Trillions US $ in the first year
- 365 transformators in danger (4800nT/min)
- regions in %, with power cuts (4 – 10 years)
- in the US: over 130 Millionen inhabitants

1. SSA: Space Catrina in the US



2. Solar Gamma Rays

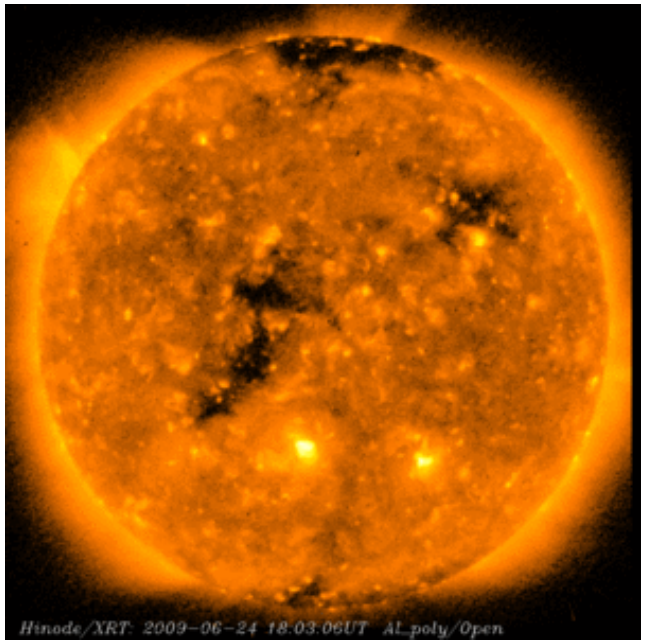


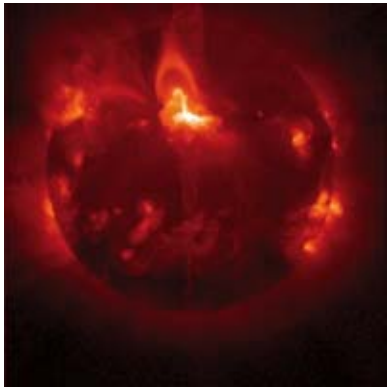
First solar gamma ray flare (nuclear reactions from ions during continously acceleration for about 2h).

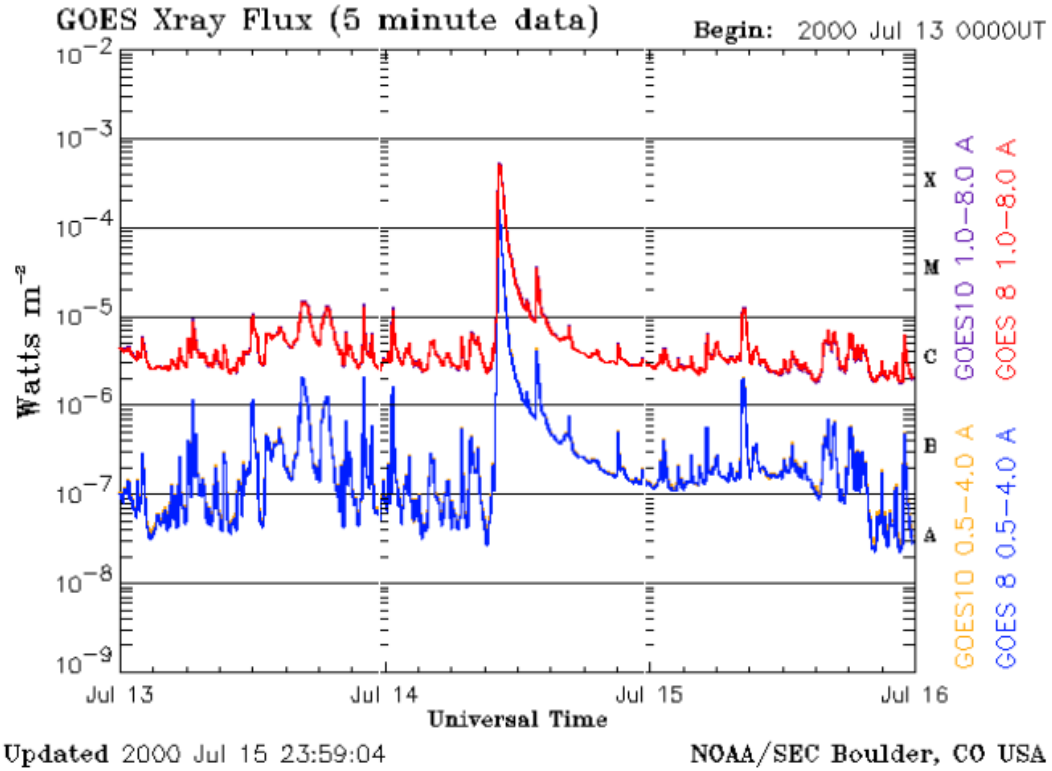
LOW NUMBER OF SOLAR GAMMA RAY IMAGES UNTIL NOW!

2. Solar Environment – X ray Images / Movies and Spectra

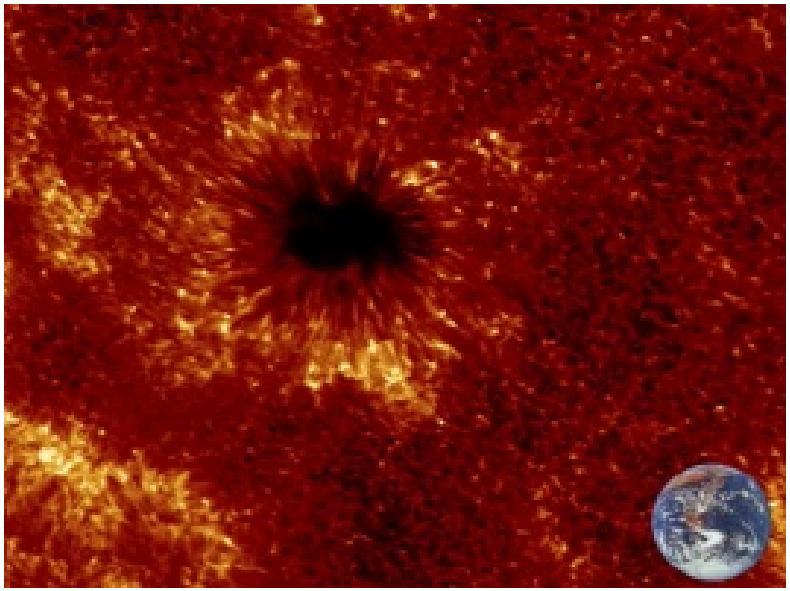
Hinode, Yohkoh, SOHO, GOES

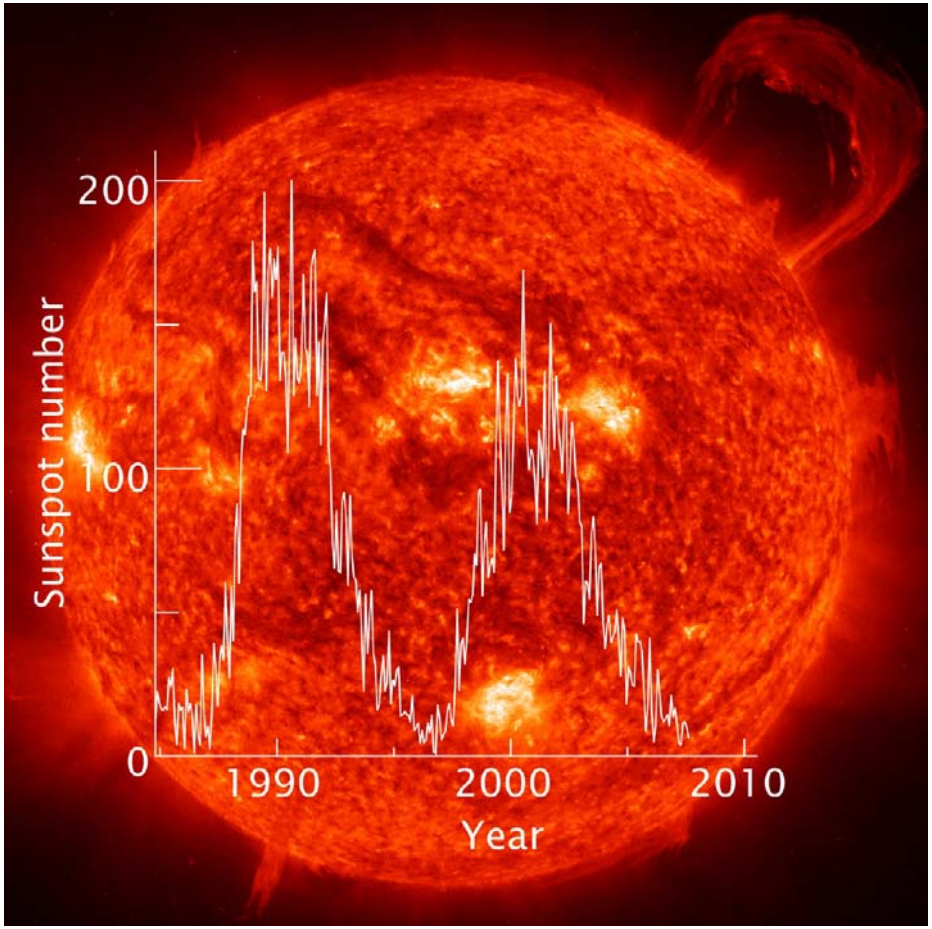




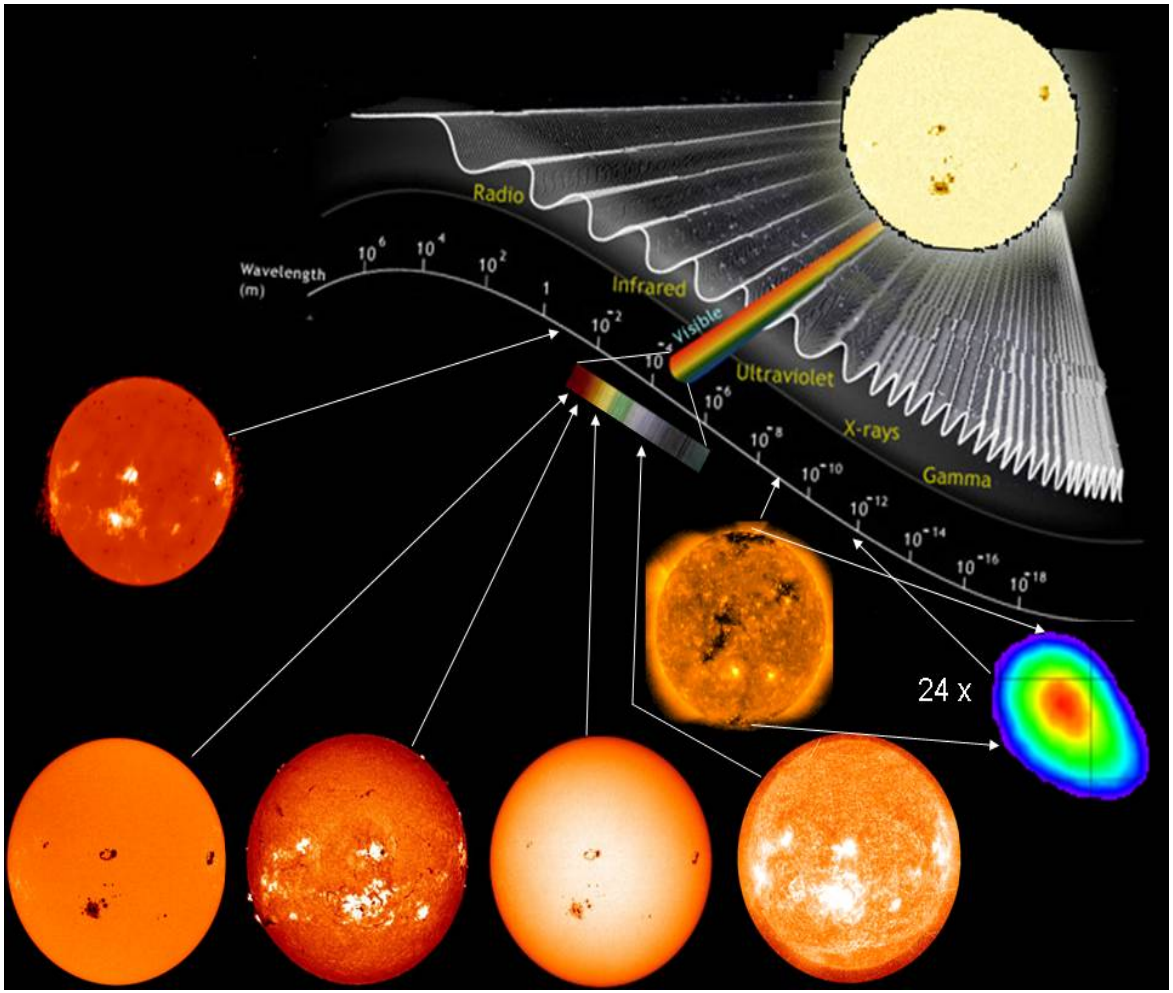


2. Solar Environment – Sunspots





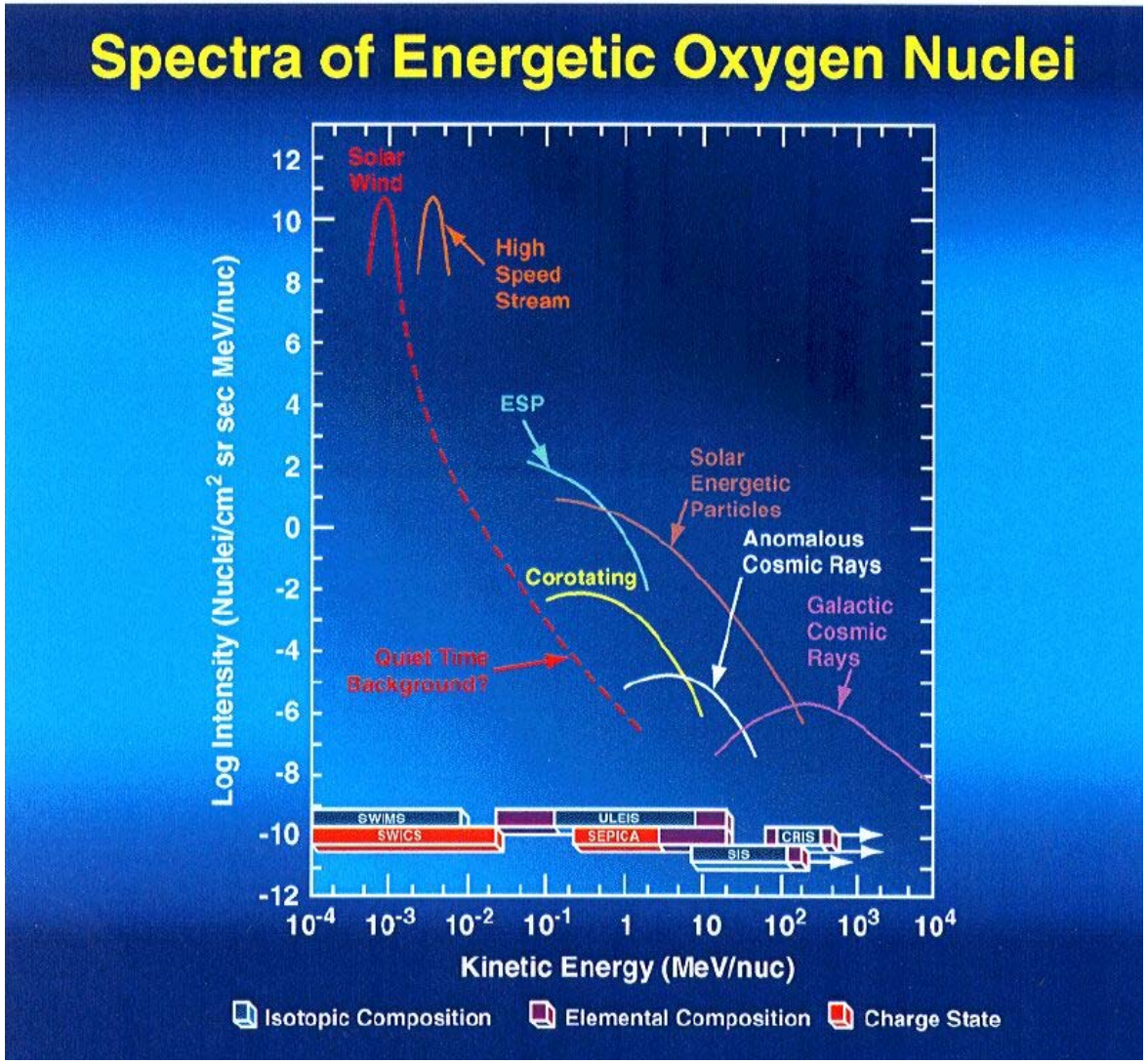
2. Sun Imaging Summary



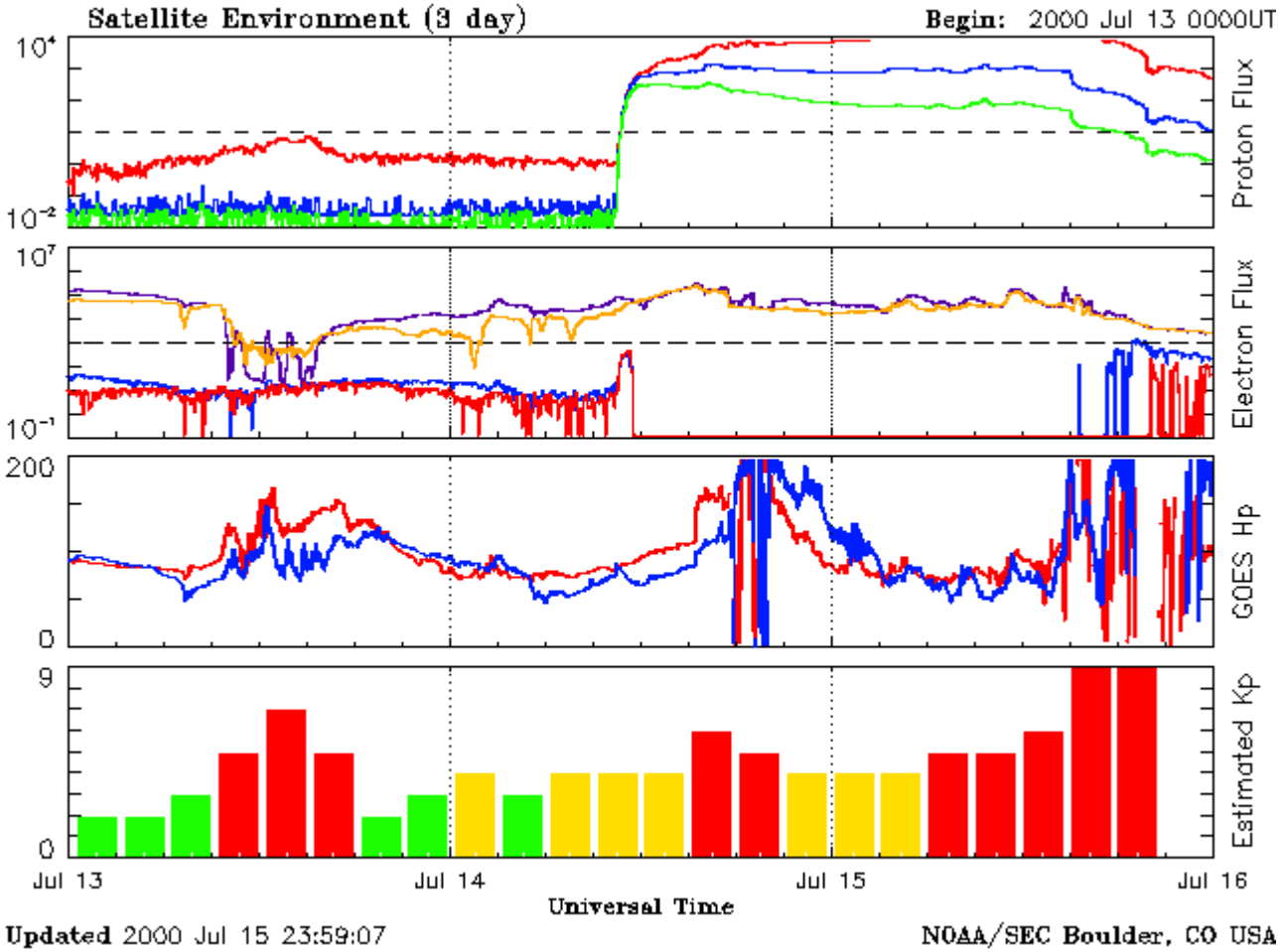
28 October 2003

High resolution solar gamma ray imaging is needed!

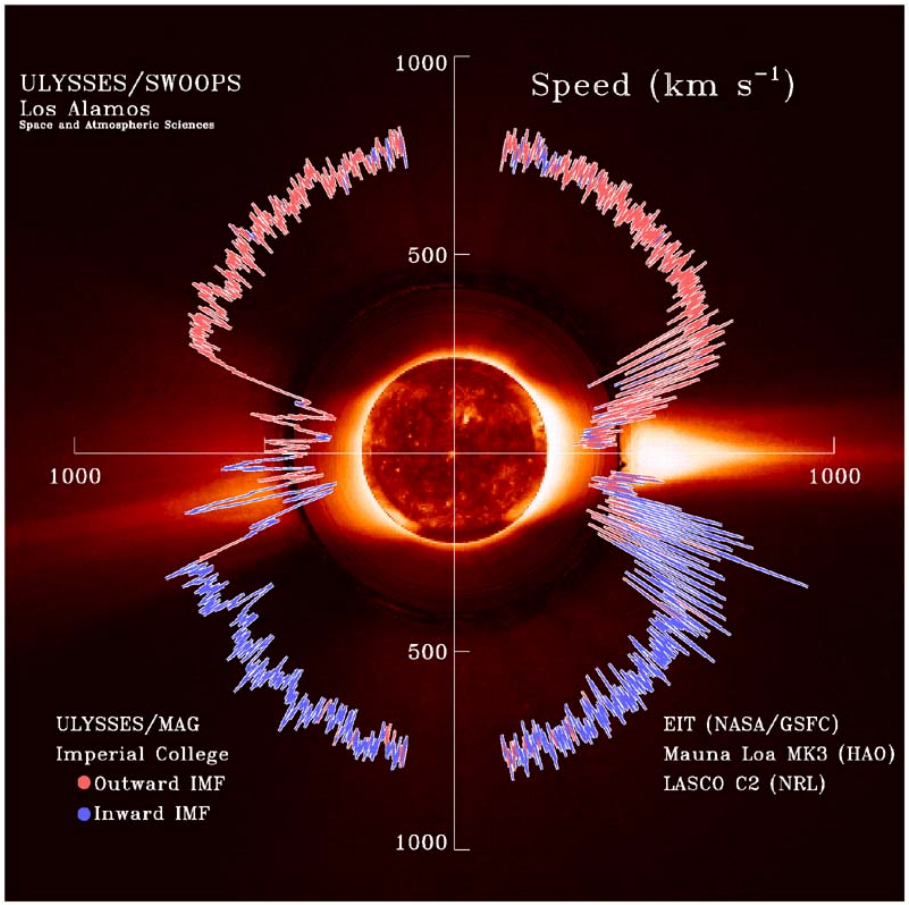
2. High Energy Galactic & Solar Cosmic Rays

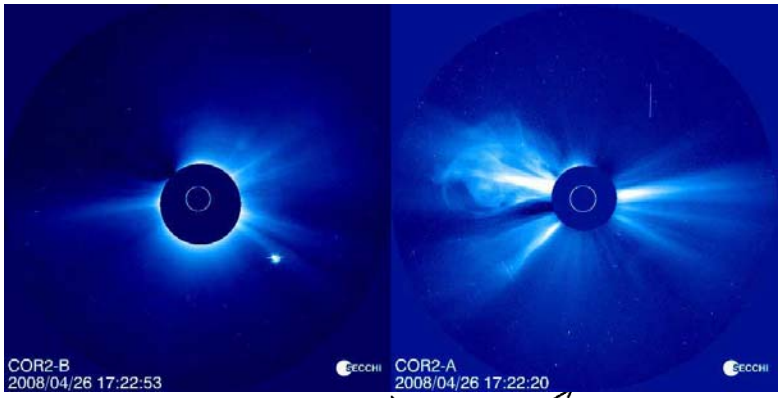


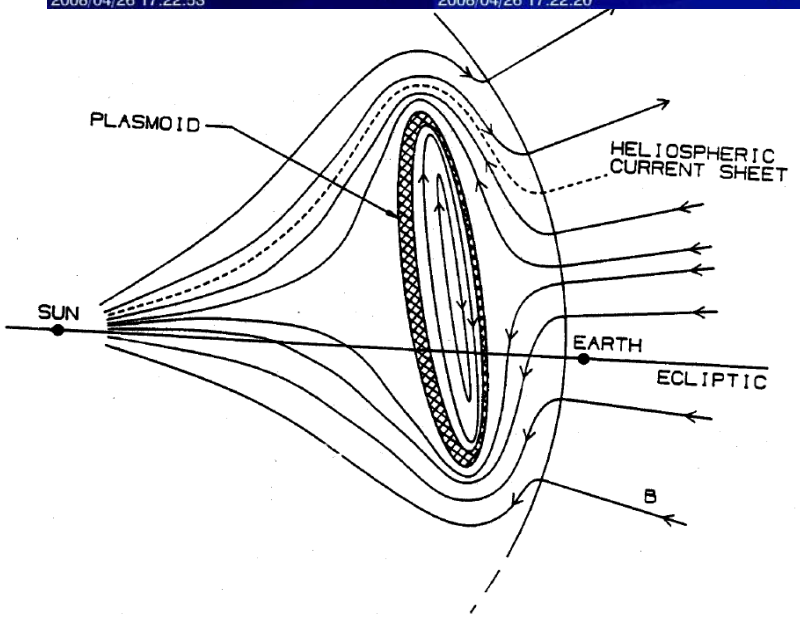
2. Solar Energetic Particles (SEP) nearby Earth



2. Solar Wind and CMEs

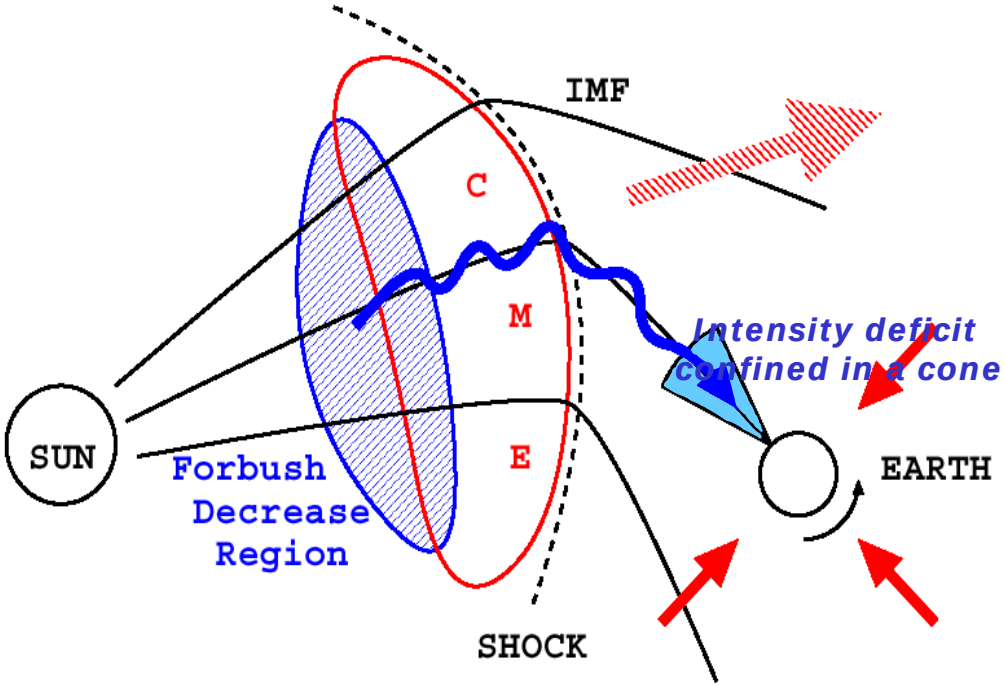


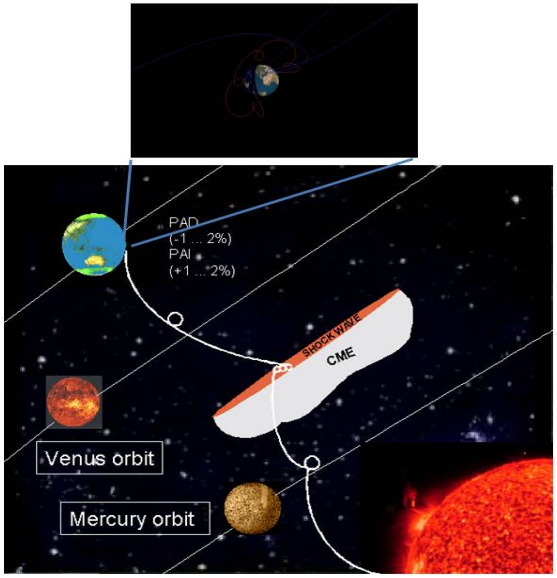




Gosling, AGU Geophys. Monogr. 1990

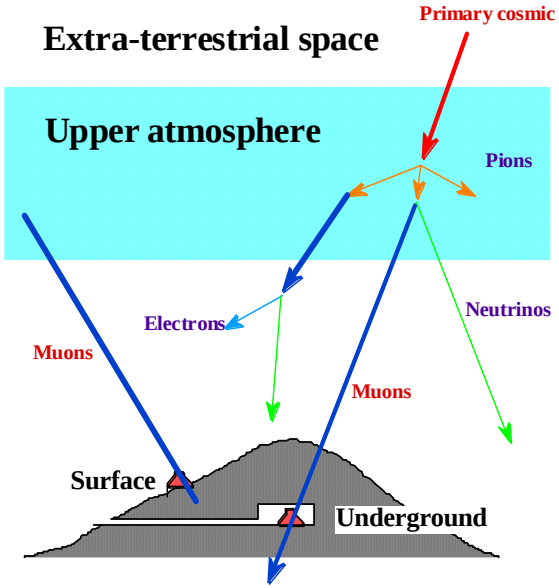
2. CME Detection via CRs



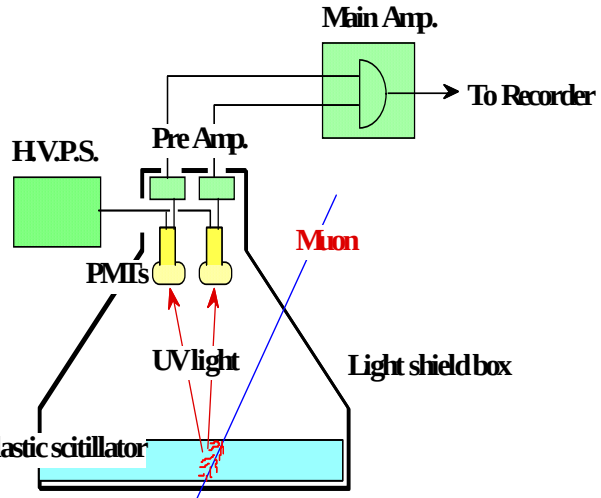


Galactic CRs interact with CME / shock, propagate from FD region to the upstream Earth with the speed of light overtaking the CME shock ahead => isotropic versus anisotropic distribution on ground and in near Earth environment.

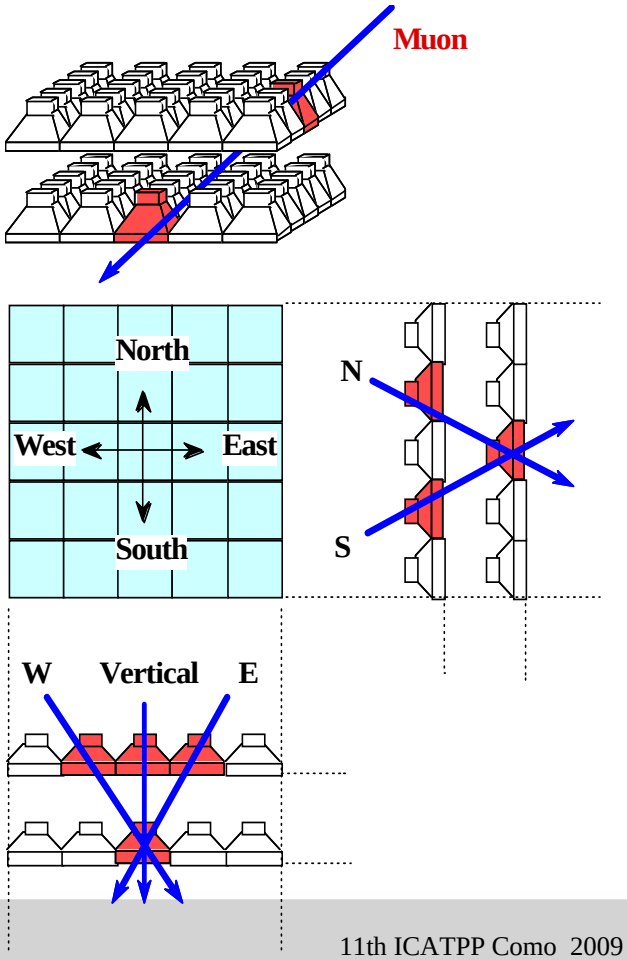
2. Principle: Muon Telescopes on Ground



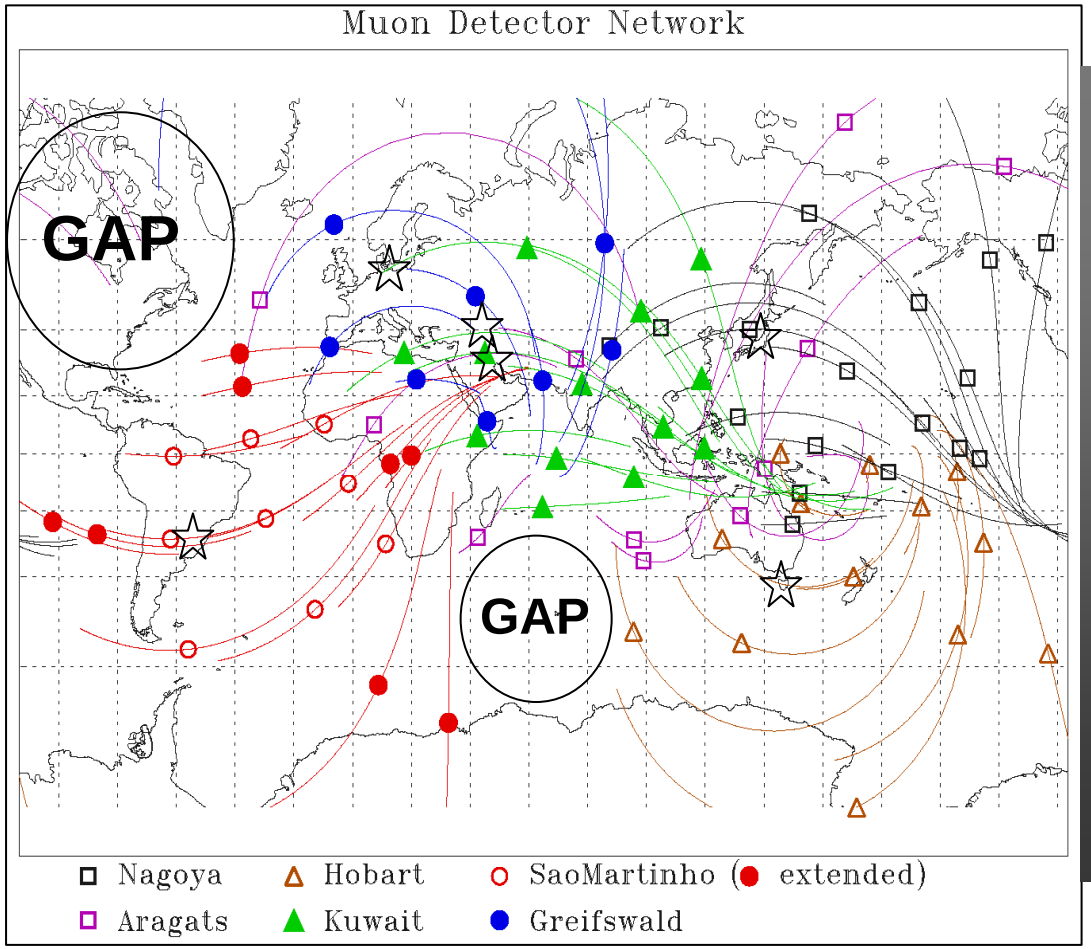
Typical energy of primary ~50 GeV for galactic cosmic rays (surface muon detector)



The detector of the Muon Telescopes at SSO / Brazil



2. GMDN: Viewing, Overlapping, Forecast Time

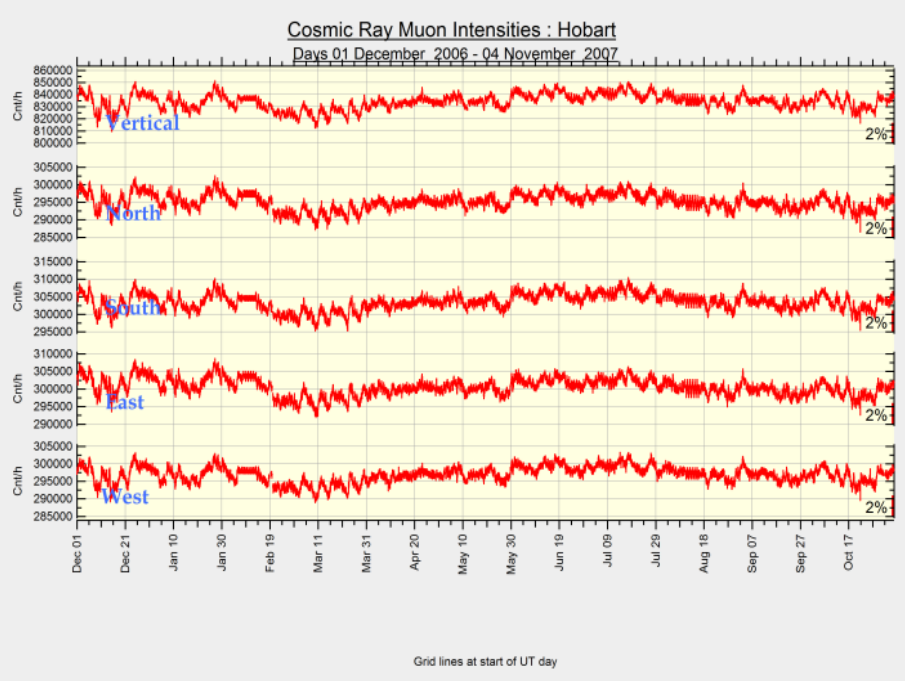


Observing directions:

Nagoya, Japan 17
Hobart, Australia 13
Greifswald, Germany 9
Aragats, Armenia 11
Kuwait, Kuwait 13
São Martinho da Serra, Brazil 17

!!! 10 – 20 hours in advance the CME detection !!!

2. GMDN: Counts / Anisotropy



$$I_{i,j}^{cal}(t) = c_{0i,j}^{0} I^{0}(t) + \xi_{x}^{GEO}(t)\left(c_{li,j}^{l}\cos\omega t_i - s_{li,j}^{l}\sin\omega t_i\right) + \xi_{y}^{GEO}(t)\left(s_{li,j}^{l}\cos\omega t_i + c_{li,j}^{l}\sin\omega t_i\right) + \xi_{z}^{GEO}(t)c_{li,j}^{0}$$

$$I^{0}(t),\ \xi_{\mathrm{x}}^{\mathrm{GEO}}(t),\ \xi_{y}^{GEO}(t),\ \xi_{z}^{GEO}(t)$$

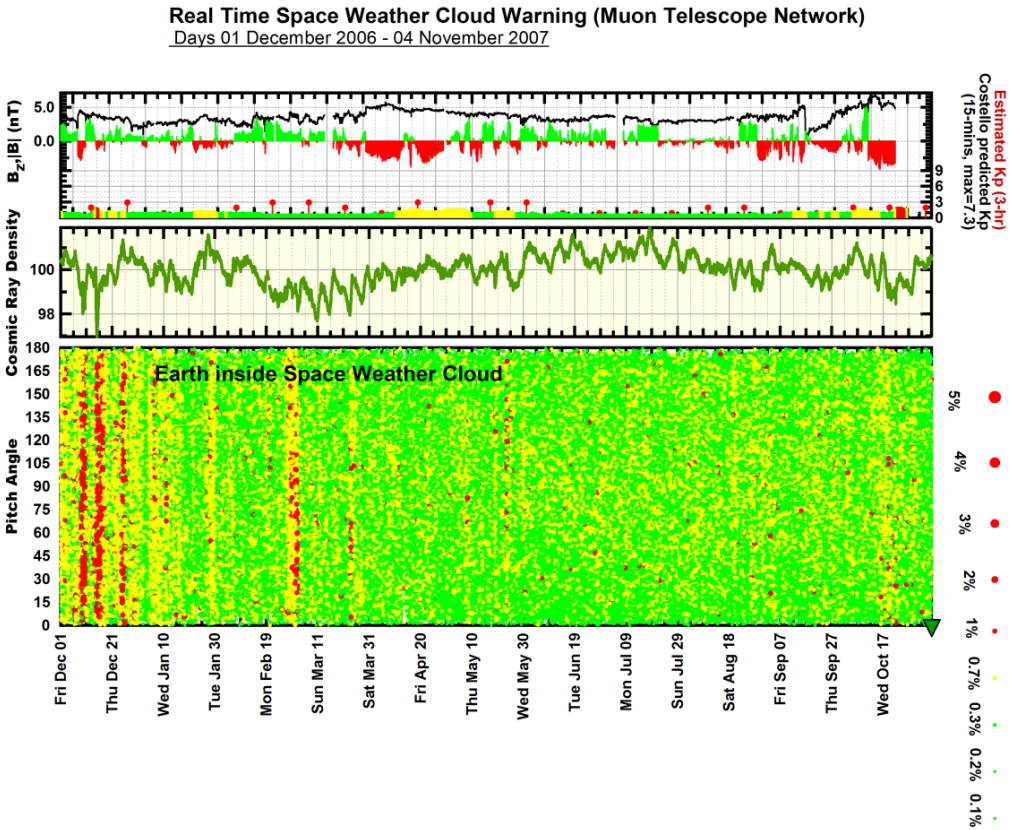
$$\omega = 2\pi / 24$$

CR muon data: K.Munakata 1, M. Duldig 2, J. Bieber 3, J. Kuwabara 3, E. Flückiger4, I. Sabbah 5, N.J.Schuch 6, F. Jansen 7

1Shinshu University Japan, 2 Australian Antartic Division Australia, 3University of Delaware, U.S.A.
4 University of Bern Switzerland, 5 University of Kuwait,

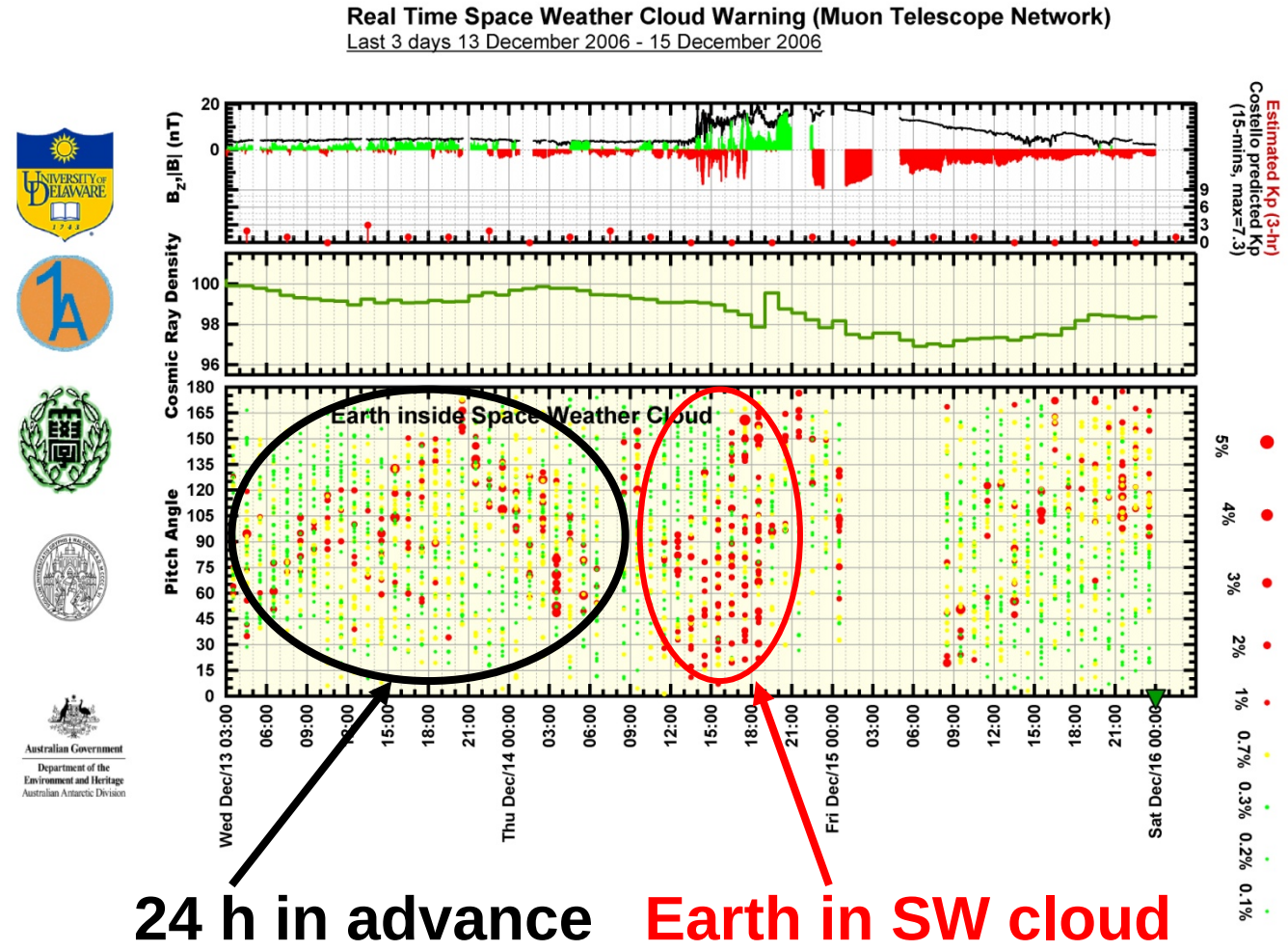
6 Brazilian Southern Space Observatory, 7 DLR Bremen

2. GMDN: SW Service from CR Anisotropy



- CR muon anisotropy (%) is a measure of interplanetary CME
- data from CR muon anisotropy: HST, NST, SMST, KPC
- space weather operator friendly displays for Bz, Kp and CR muon anisotropy
- real time service: ACE, CR, CME

2. GMDN: 13 – 15 December 2006

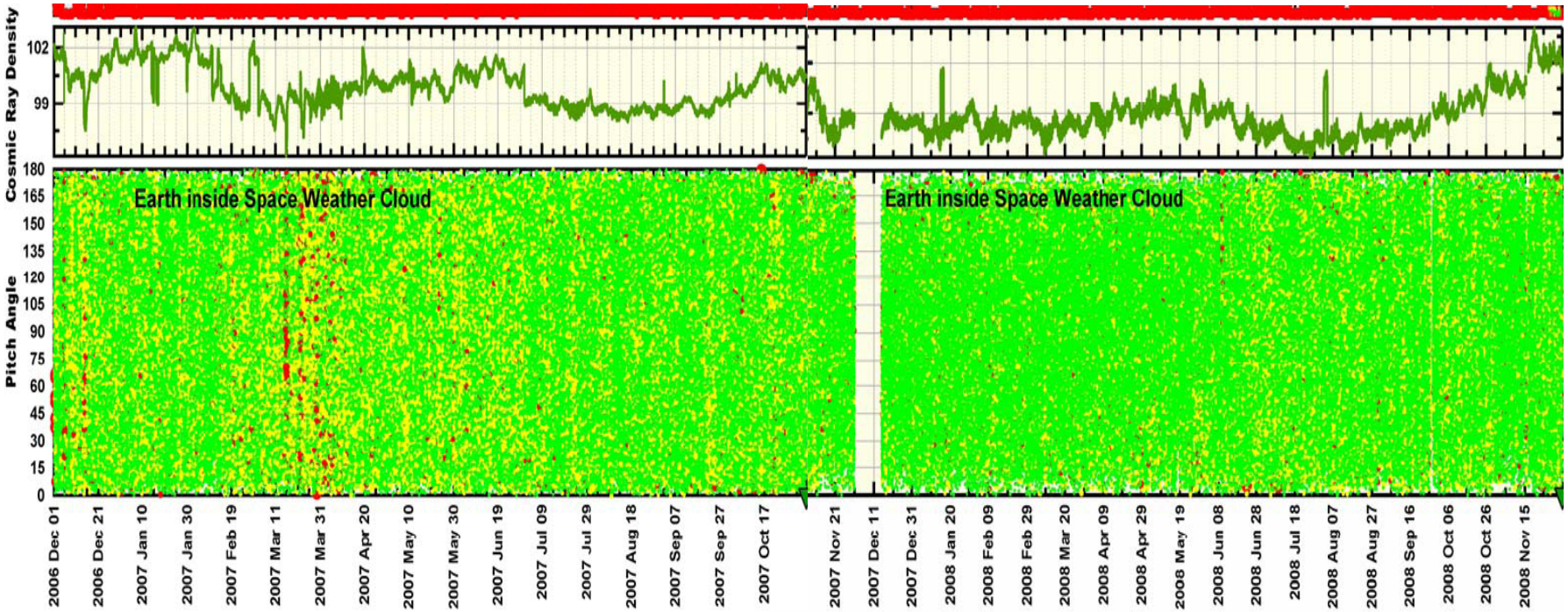


2. Service with GMDN

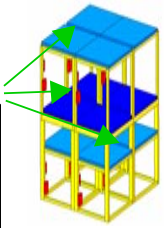
- user friendly service: real time, early, monthly, 27, 3 days

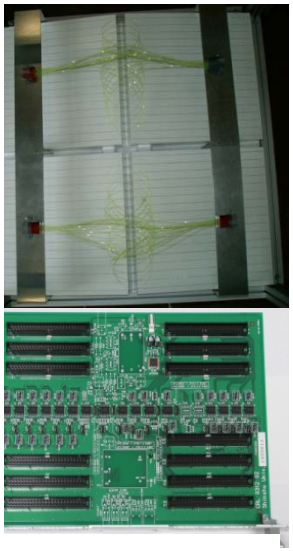
  and others plots from GMDN

- University of Delaware / Bartol and DLR Institute of Space Systems / Bremen



3. GMDN: No CME Images - But with Space Based Technology!

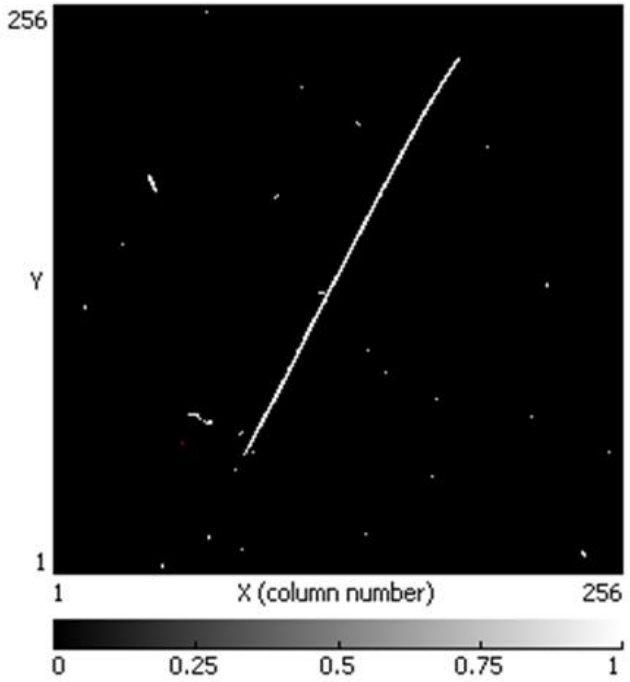


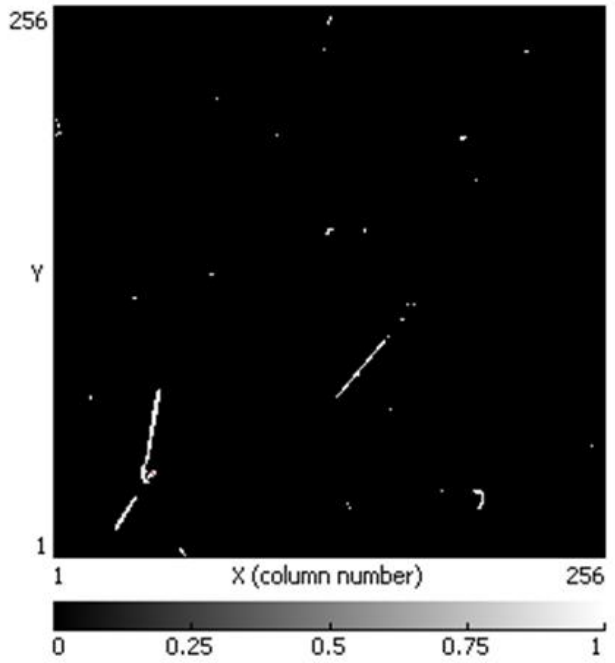


Change from UV telescopes technology towards CR telescopes based on highly miniaturzed detector technology:

Medipix / Timepix

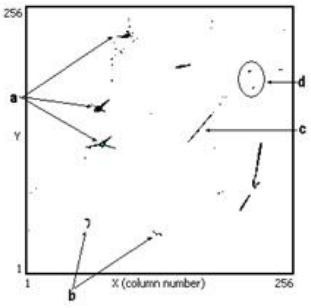
3. Medipix 2 and CR Balloons Flight





a – heavy charged particles

b – slow light charged particles



c – fast light charged particles

d – x and low energy gamma rays

3. NeSTec (New Space Technology) – EU / FP6 Space Proposal

DLR

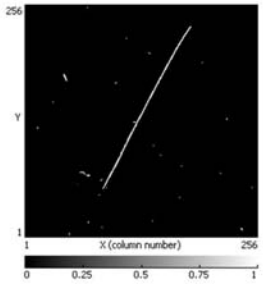
DESY

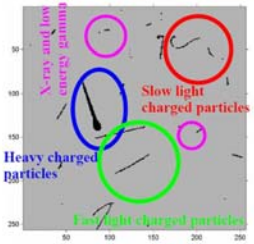
IEP SAS SPACE PHYSICS

TU Delft
Delft University of Technology

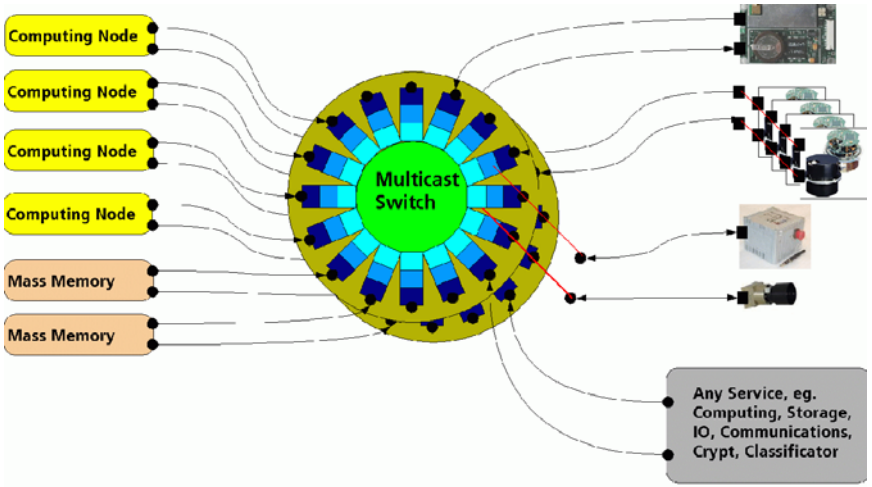
MPS
Max-Planck-Institut für Sonnensystemforschung

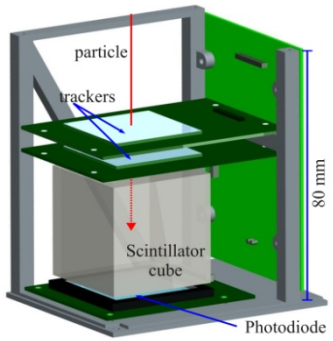
cosine

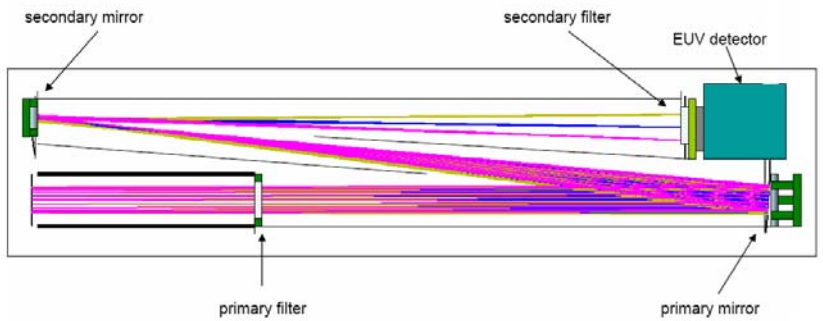




Medipix







Conclusions

2010 Bremen: 38th COSPAR Scientific Assembly, SSA session !